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**Elliott**

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(54) **SMART PIXEL ADDRESSING**

USPC ..... 345/214  
See application file for complete search history.

(75) Inventor: **Grant Arthur John Elliott**, Tai Po (HK)

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(73) Assignee: **Barco Inc.**, Duluth, GA (US)

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**Related U.S. Application Data**

(60) Provisional application No. 61/061,338, filed on Jun. 13, 2008, provisional application No. 61/061,347, filed on Jun. 13, 2008, provisional application No. 61/061,353, filed on Jun. 13, 2008, provisional application No. 61/061,358, filed on Jun. 13, 2008, provisional application No. 61/061,365, filed on Jun. 13, 2008, provisional application No. 61/061,369, filed on Jun. 13, 2008.

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(57) **ABSTRACT**

A display unit has modular groups of light emitting elements or pixels. A light emitting element in the display unit can be used as a light receptor for accepting control information without needing to connect the display unit to a network or a controller.

**47 Claims, 7 Drawing Sheets**

(51) **Int. Cl.**

**G06F 3/038** (2013.01)

**G01J 3/28** (2006.01)

**G06F 3/14** (2006.01)

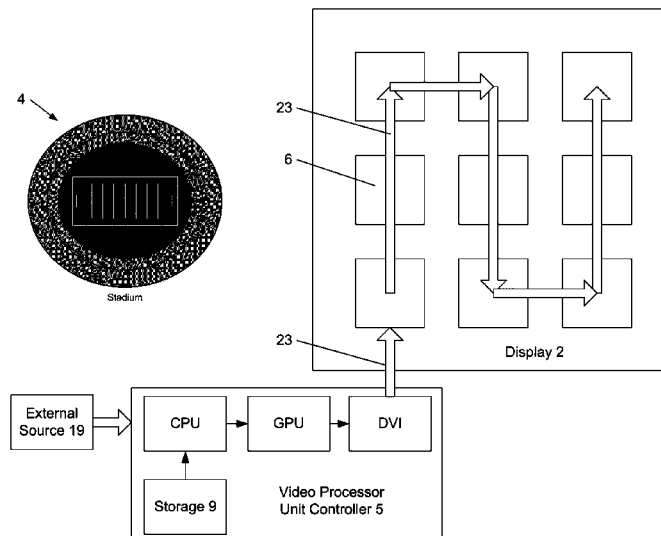
**G09F 9/302** (2006.01)

(52) **U.S. Cl.**

CPC ..... **G01J 3/28** (2013.01); **G06F 3/1446** (2013.01); **G09F 9/3026** (2013.01); **Y10T 29/49826** (2015.01)

(58) **Field of Classification Search**

CPC ..... G06F 3/038



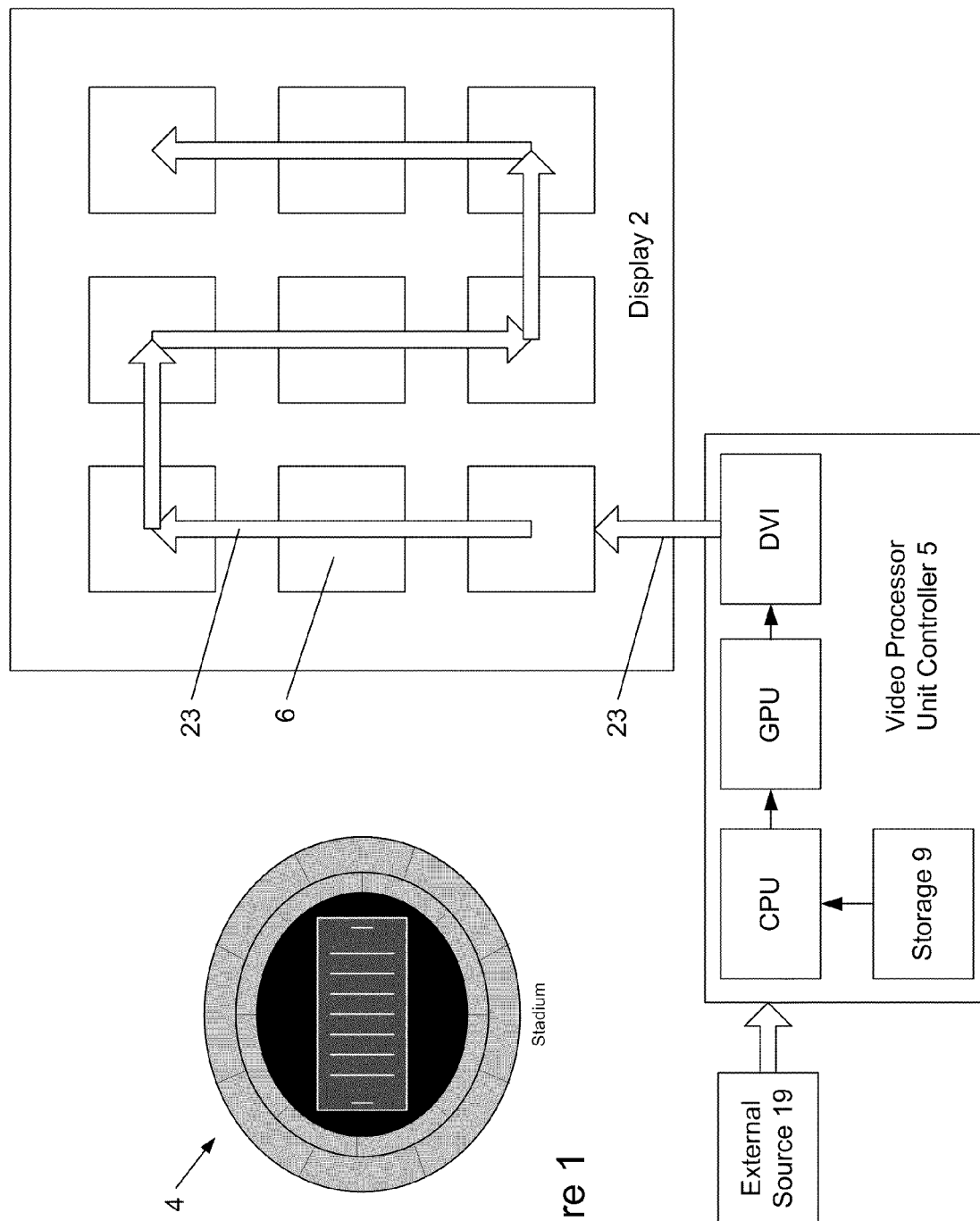


Figure 1

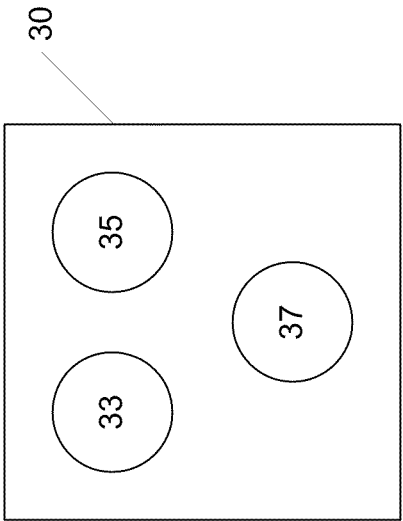


Figure 3

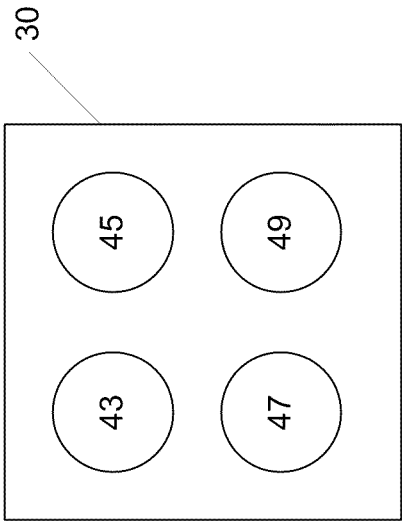


Figure 4

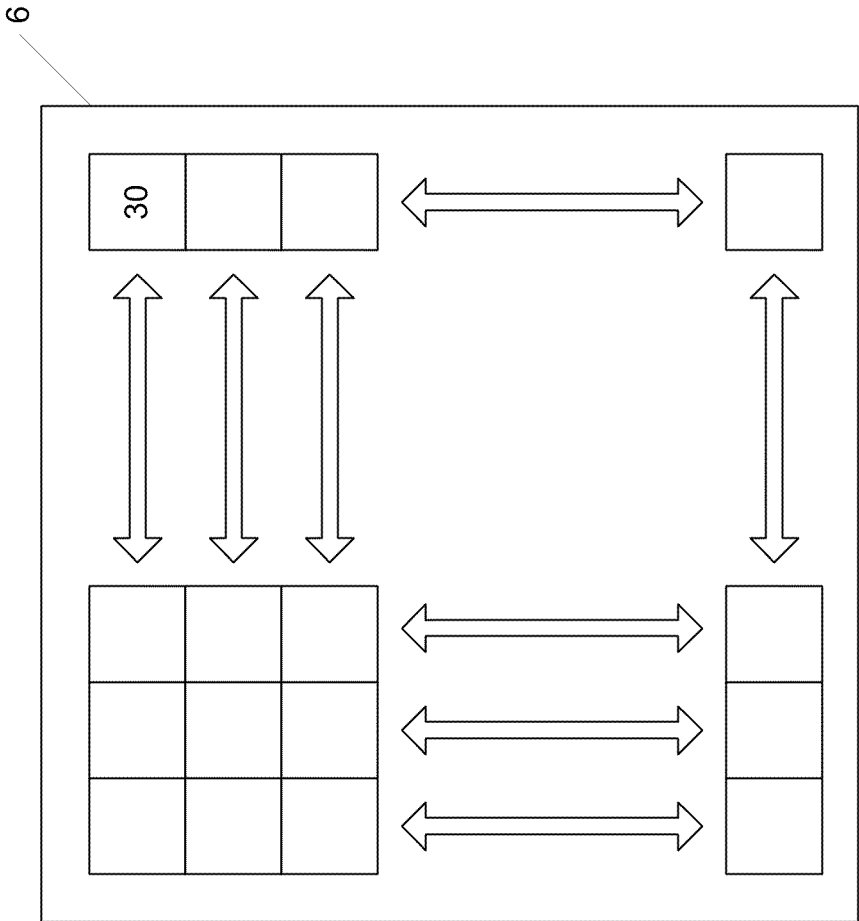


Figure 2

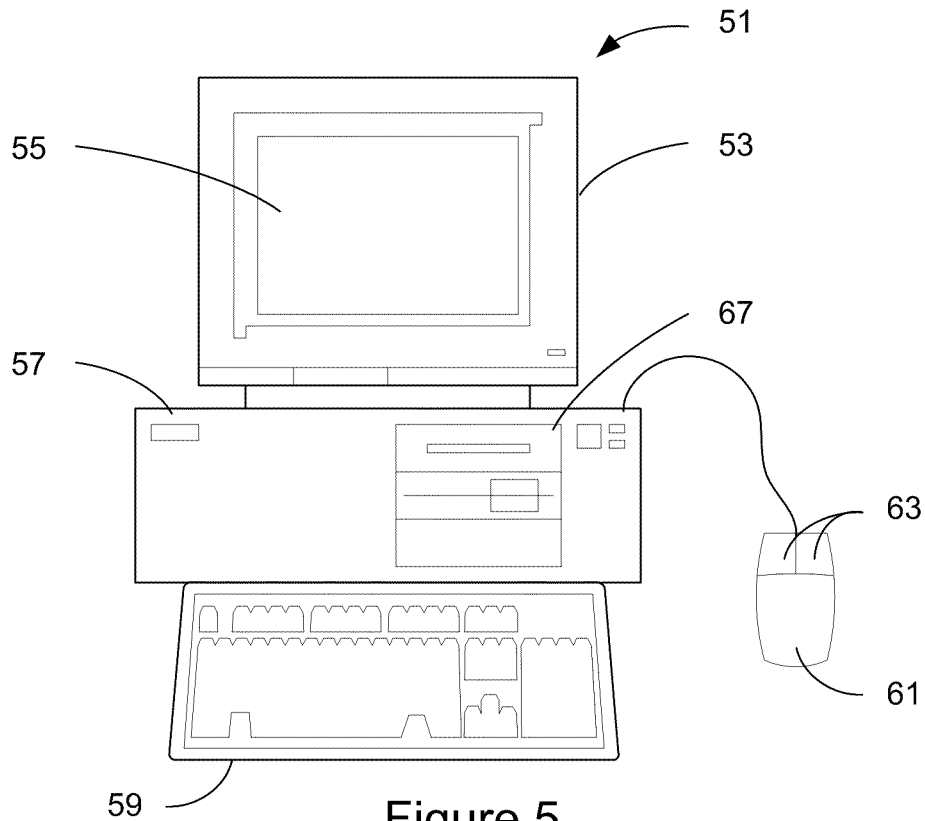


Figure 5

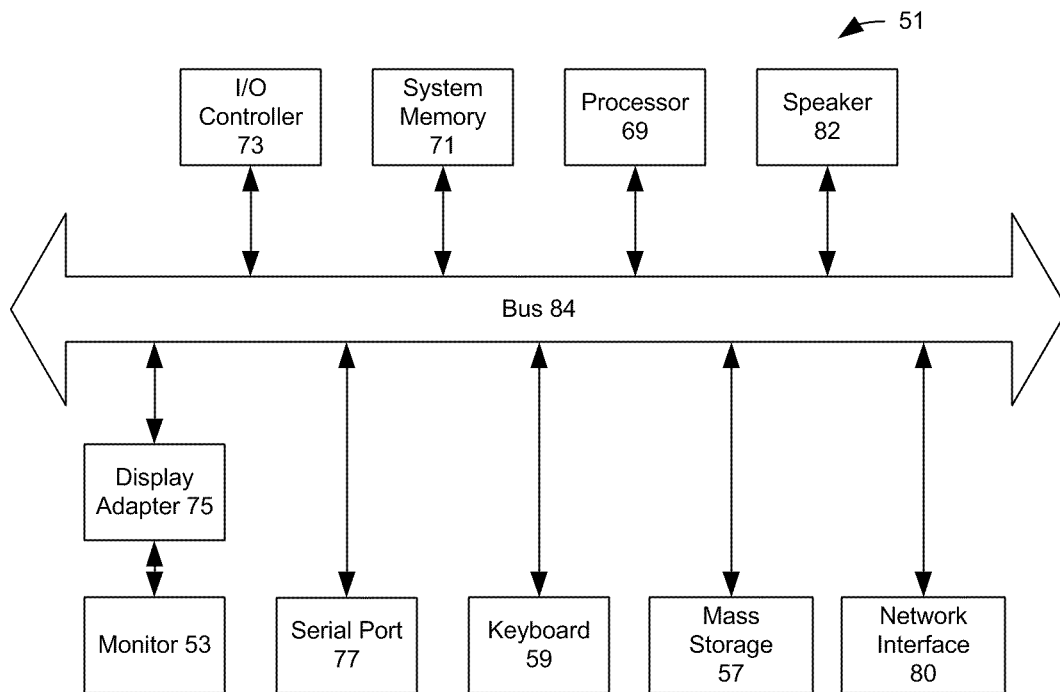


Figure 6

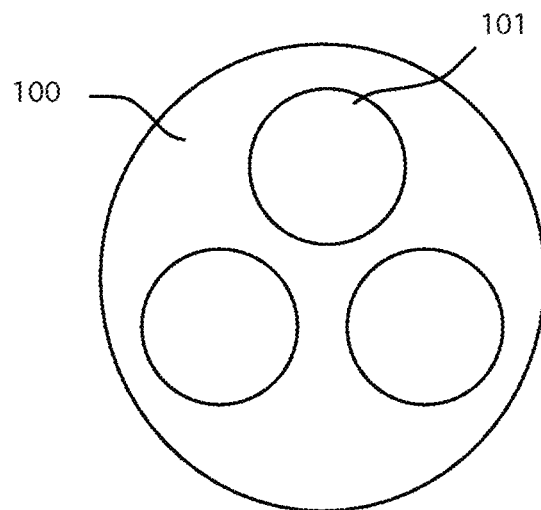


Figure 7

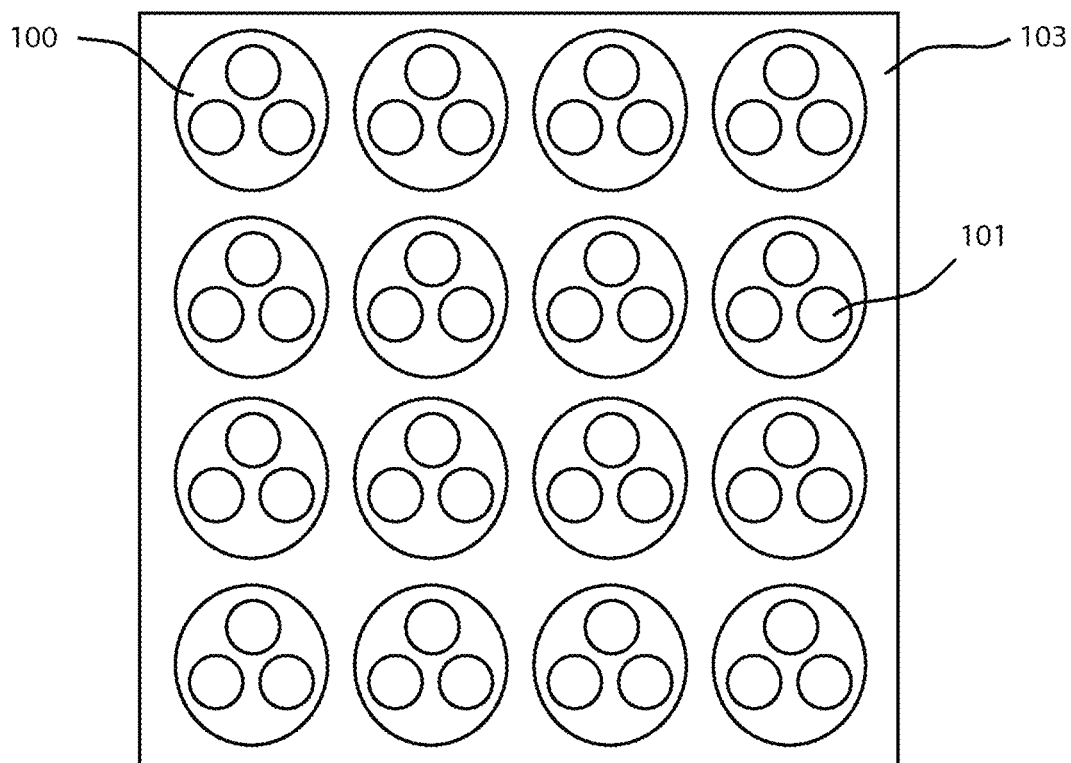


Figure 8

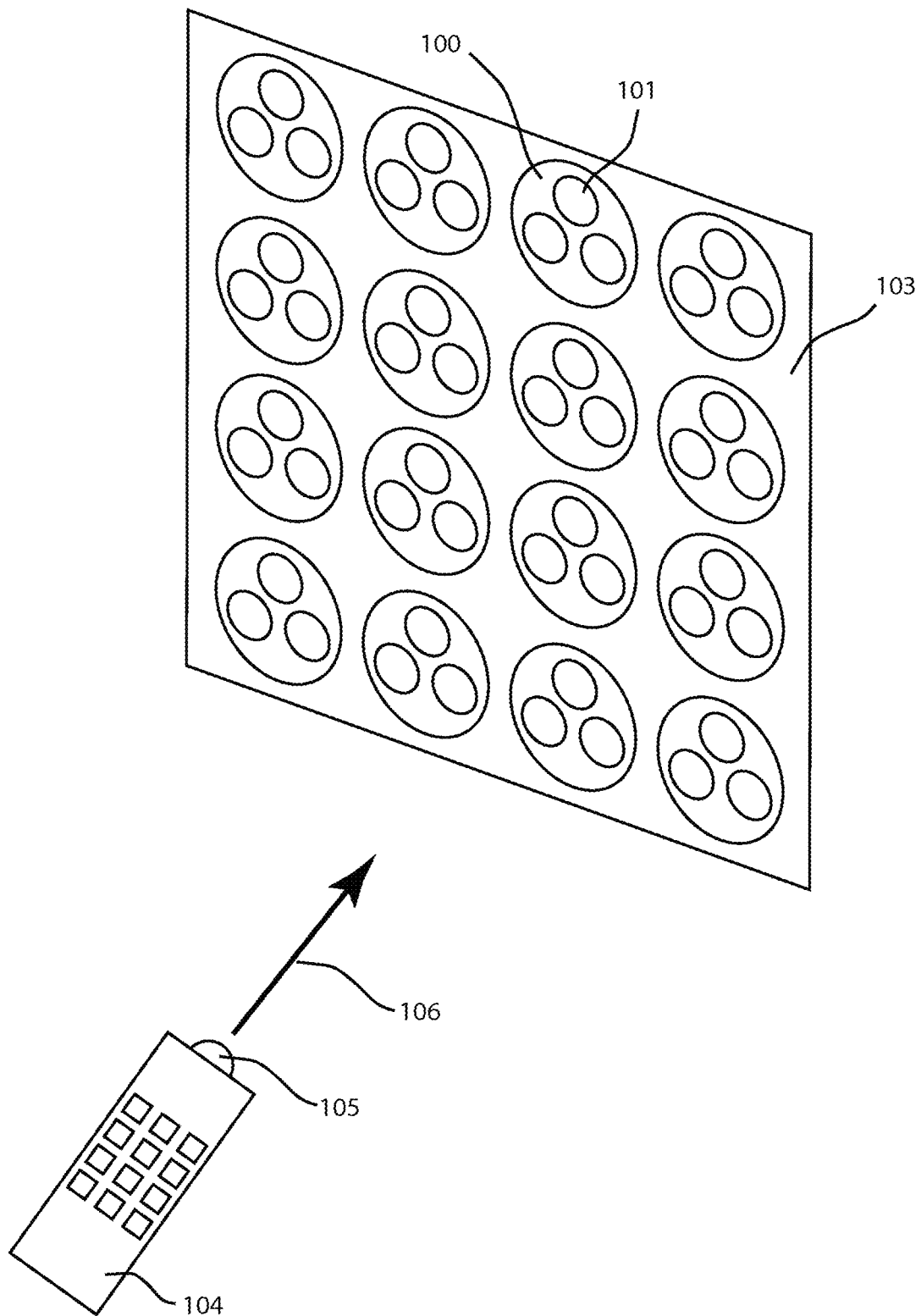


Figure 9

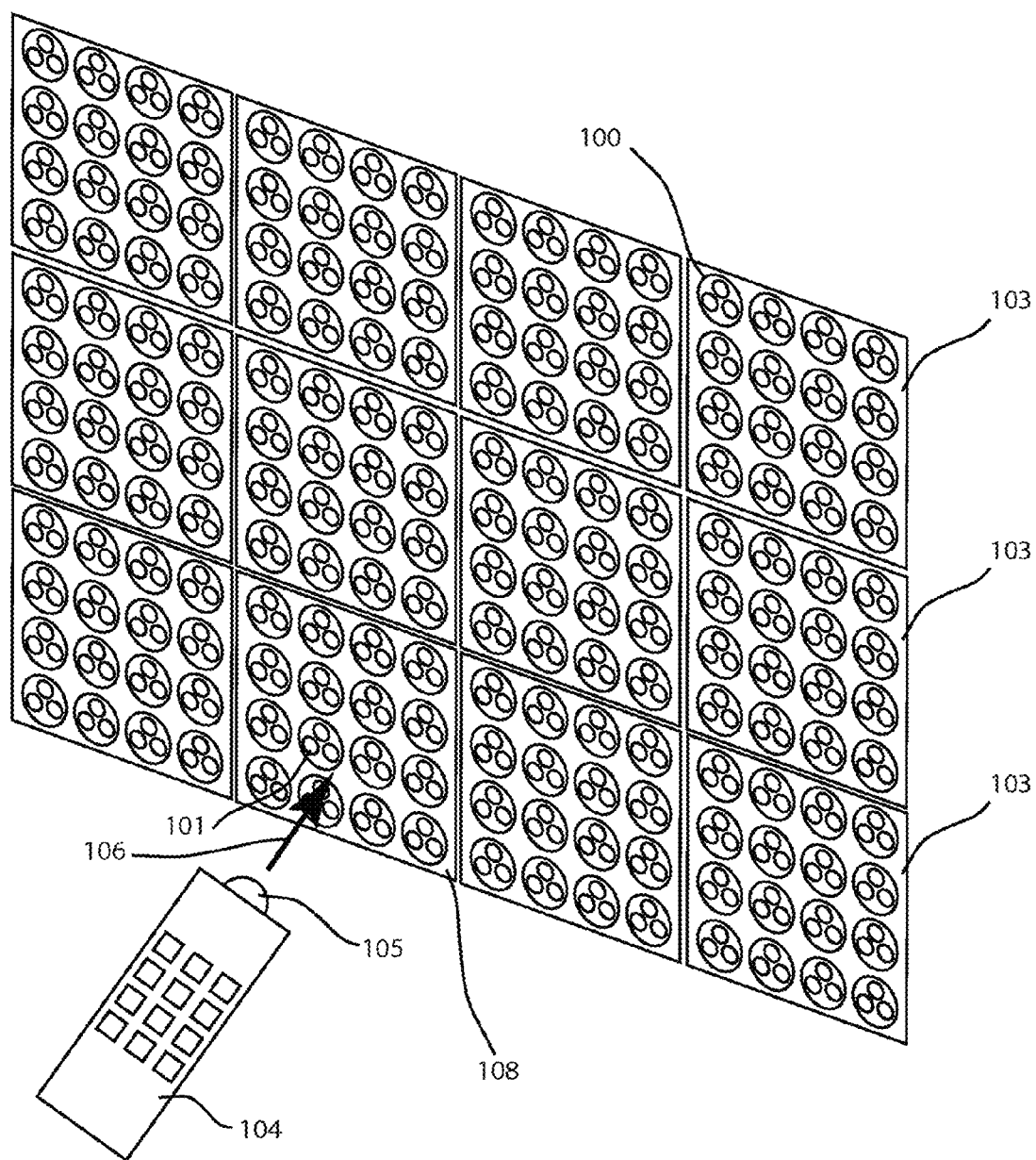


Figure 10

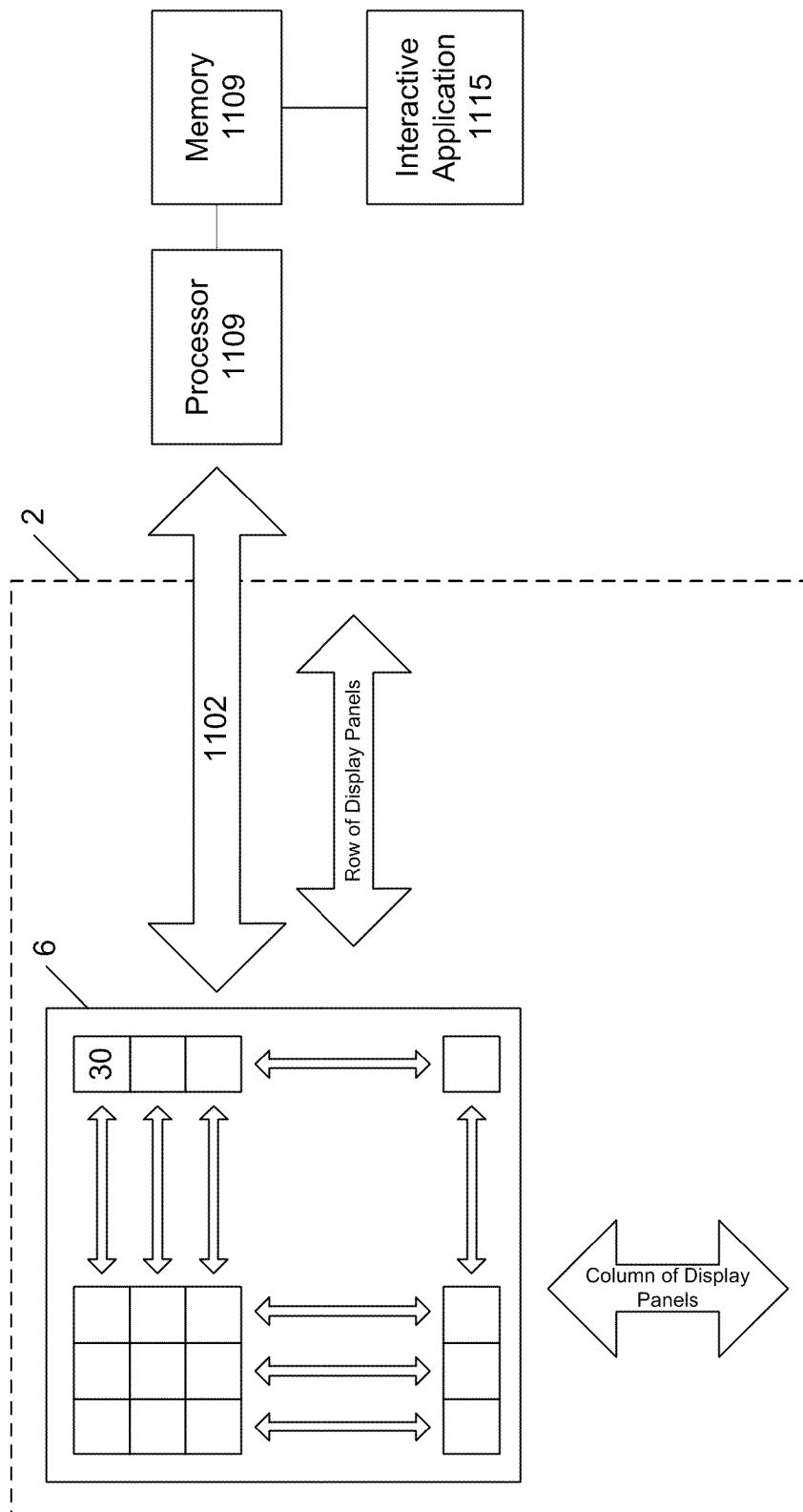


Figure 11



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**SMART PIXEL ADDRESSING****CROSS-REFERENCE TO RELATED APPLICATIONS**

This patent application claims the benefit of U.S. provisional patent applications 61/061,338; 61/061,347; 61/061,353; 61/061,358; 61/061,365, and 61/061,369, all filed Jun. 13, 2008, which are incorporated by reference along with all other references cited in this application.

**BACKGROUND OF THE INVENTION**

This disclosure generally relates to display units and particularly to a display unit having groups of light emitting elements in which a data distribution system is utilized. This disclosure provides an improved method of providing interactive communication with a pixel module of such a display. This disclosure further provides improvements allowing interactive communication with the pixel modules both to aid maintenance and to provide new operational features.

Display units for entertainment, architectural, and advertising purposes have commonly been constructed of numbers of light emitting elements, such as LEDs or incandescent lamps mounted onto flat tiles. The light emitting elements may be selectively turned on and off to create patterns, graphics, and video displays for both informational and aesthetic purposes. These displays may be constructed as tiles or large panels that are assembled in position for a specific entertainment show or event or as an architectural or advertising display.

When such a display is used for an event or theatrical production, it is desirable that the display be easily removable, for example, in between scenes of a play or theatrical event, as the needs of the production dictate. Systems may use a tile based structure where a tile, typically around 61 centimeters×61 centimeters (i.e., 2 feet×2 feet), can be lifted by hand and positioned. Accurate positioning of the tiles may be a time consuming and complex process involving skilled personnel.

Displays of these types may be constructed at different resolutions where the spacing between the light emitting elements can be varied. It may also be a requirement to change this spacing at different points on the display.

Many of these systems require large numbers of light emitting elements or pixels acting independently and, thus, require robust high speed data distribution systems, often driven by computer derived data or video signals. A display constructed in this manner using modules is flexible in that it allows the user to reconfigure the display into different shapes and formats; in some cases it can also allow the replacement of a single faulty module without having to replace the entire display. However, in such a case, there is a need for a means of quickly addressing or setting the modules so that they will respond to the correct data appropriate to their physical or assigned position in the entire display.

Some methods for assigning these addresses use physical switches or settings on the module itself; a computer network which allows configuration from a master controller; or a connection scheme which can automatically allocate addresses dependant on the order of connection of modules. It would be advantageous if there was a means to communicate with a single module without utilizing the as yet unaddressed data link.

**BRIEF SUMMARY OF THE INVENTION**

The present invention relates to a light emitting element in a light emitting display having the ability to be utilized as both

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a light emitter and light receptor. The light emitting element can receive a signal to perform a particular action and a processor can decode the signal. According to one aspect of the invention, a light emitting display unit includes a pixel module having a light emitting element, where the light emitting element is configured to both emit light and to detect light. The light emitting element may be configured to receive a signal. The signal may be a coded signal. The coded signal may be coded in pulse-width modulation, pulse-amplitude modulation, phase modulation, amplitude modulation, or frequency modulation.

In one embodiment, the light emitting display further includes an input element configured to emit the signal. The input element may include a light emitting element configured to emit the signal. The light emitting element of the input element includes a light emitting diode or a laser. The signal includes infrared radiation, ultraviolet radiation, visible light, or reflect light emitting from the light emitting element of the input element. The light emitting element of the pixel module includes a light emitting diode. The light emitting diode can include a red, green, or blue light emitting diode. In another embodiment, the light emitting display further includes a processor electrically connected to the pixel module and configured to supply an address for the pixel module.

According to another aspect of the invention, a light emitting display system includes a plurality of display units, where each of the plurality of display units includes a light emitting element configured to emit light and configured to detect light. In an embodiment, each of the plurality of light emitting elements is configured to receive a signal.

According to another aspect of the invention, a method of communicating with a light emitting display unit includes receiving a signal with a light emitting element disposed on a pixel module of the light emitting display unit, processing the signal with a processor electrically connected to the light emitting display unit, producing a request of address by the processor for the pixel module, and addressing the pixel module of the light emitting display unit based upon the request of address.

In an embodiment, the pixel module is addressed by the processor. In another embodiment, the pixel module is addressed by another processor. In yet another embodiment, the method of communicating with the light emitting display unit further includes producing the signal with an input element and authorizing the input element to communicate with the light emitting display unit.

According to another aspect of the invention, a method of communicating with a light emitting display unit includes receiving a signal with a light emitting element disposed on a pixel module of the light emitting display unit, processing the signal with a processor electrically connected to the light emitting display unit, producing an output by the processor for the pixel module, and controlling the pixel module of the light emitting display unit based upon the output.

In an embodiment of the invention, controlling the pixel module includes controlling a color of light emitted from the light emitting element of the pixel module or controlling an intensity of light emitted from the light emitting element of the pixel module. In another embodiment of the invention, the signal includes infra-red radiation, ultra-violet radiation, visible light, or reflect light emitting from the light emitting element of the input element.

Other objects, features, and advantages of the present invention will become apparent upon consideration of the following detailed description and the accompanying drawings, in which like reference designations represent like features throughout the figures.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a specific implementation of a system incorporating a technique of the invention.

FIG. 2 shows a panel of a multiple panel display.

FIG. 3 shows a first pixel element implementation.

FIG. 4 shows a second pixel element implementation.

FIG. 5 shows a system of the present invention for performing a technique of the invention.

FIG. 6 shows a simplified system block diagram of a computer system used to execute code for a technique of the invention.

FIG. 7 is a diagram of a single pixel module in accordance with an embodiment of the invention.

FIG. 8 is a diagram of a single display module of an LED display in accordance with an embodiment of the invention.

FIG. 9 is a diagram of an interactive device and a single display module in accordance with an embodiment of the invention.

FIG. 10 is a diagram of the interactive device and multiple display modules in accordance with an embodiment of the invention.

FIG. 11 shows a system with multipanel display with combination light emitters and photodetectors that are responsive to input sources which is not an active light source.

## DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 shows a specific implementation of a system incorporating a technique of the invention. The system has a large video display 2 that is used in such environments as a sports stadium 4 or arena (e.g., baseball, football, basketball, hockey, and soccer), concert venues and theaters, entertainments complexes, retail environments (e.g., shopping malls), outdoor venues and architectural buildings (e.g., billboards, signage, and side of buildings). For example, the display can be placed in the outfield of a baseball stadium to show video of a player at bat, highlights of the play, advertisements, and other video or graphics that provide information (e.g., statistics of the player at bat) or entertainment (e.g., show fireworks when a player hits a home run) the fans.

Display 2 is made of a number of display panels 6. The figure shows nine display panels arranged in an array of rows and columns. However, the display can have any number of panels, typically more than nine, but depending on the size of a panel, can be fewer than nine panels or even a single panel.

The panels are typically joined together and interlocked to form a single contiguous panel. The panels can be arranged and interlocked in any orientation, such as a rectangular screen in landscape orientation, a rectangular screen in portrait orientation, or a long banner strip. Panels can also be arranged into separate sections, containing gaps (such as with landscaping or fountains between each screen section), and these noncontiguous panels can be controlled simultaneously.

An implementation of a display panel is the Cobra™ display panel products by Element Labs, Inc. The display panel uses light emitting diode (LED) technology. Each pixel of the panel has four LEDs of different colors (e.g., red, green, blue, and cyan). Some more details on the Cobra products can be found in U.S. patent application Ser. No. 12/415,627, filed Mar. 31, 2009, Ser. Nos. 12/484,200 and 12/484,201, filed Jun. 13, 2009, and U.S. provisional patent applications 61/072,597, filed Mar. 31, 2008, and 61/170,887, filed Apr. 20, 2009, which are incorporated by reference.

Other display panel technologies which may be used include organic LED (OLED), liquid crystal display (LCD), plasma, digital light processing (DLP), video projection, or cathode ray tube (CRT).

The display is driven by a video processor unit controller 5, which includes a central processing unit (CPU), graphics processing unit (GPU), and Digital Visual Interface (DVI) interface output. A GPU can be connected to any number DVI ports (e.g., one, two, three, four, or five or more). If more DVI ports are needed, more GPUs can be added, each GPU being connected to additional DVI ports. The CPU and GPU process video from a source such as internal storage 9 or external storage 19.

The CPU may be one or more integrated circuit processors manufactured by Intel (e.g., Core™ 2 Duo, Core i7, or Atom), AMD (e.g., Athlon™ or Phenom™ product line), or International Business Machines Corp. (IBM) (e.g., PowerPC product line), or combinations of these.

The GPU may include one or more integrated circuits manufactured by Nvidia Corporation, Advanced Micro Devices (AMD) (e.g., ATI product line), or Intel Corporation (e.g., Intel Graphics Media Accelerator product line), or combinations of these.

In an implementation, video processor unit controller 5 communicates via a display interface such as a DVI output interface (or DVI transmitter) to display 2 and its panels via a DVI interconnection 23. The panels of the display have a DVI input interface or DVI receiver. Other display interface technologies may be used such as HDMI, DFP, DisplayPort, SDI, VGA, and others. However, display interface technologies limit a distance between controller 5 and the display because of interference and noise, which become more significant as the distance increases. Typically a DVI interface can be used for distances of about five meters (about 16 feet). Distances can be greater than five meters depending on the quality of the cabling and strength of the display interface signal transmitters.

Some large displays 2 in large venues such as a stadium may be connected using long length communication channels. When longer distances are needed, a DVI repeater or driver (which amplify the signal) or other longer communication channel technology can be used in conjunction with the DVI connection interface. In particular, the DVI interface can be converted to a fiber optic link or another twisted pair technology (e.g., Ethernet, 802.3 Ethernet over fiber optic cable, or others) by adding interface electronics in the interface path. Alternatively, the controller can be connected using another (nondisplay) interface technology such as Ethernet or USB to the display. Then controller 5 can then be located in a control booth behind and above home plate, while the display is behind center field.

The video source can be stored on internal storage 9, which can be a hard drive or solid state drive (SSD) which can be a video file or other file with instructions on what to display. Video rendering may be performed in real time by the GPU. Software or firmware executing on controller 5 reads the video file and handles performing the operations to display the video on the display. The video may be live video stream, prerecorded video, or text such as scoreboard information.

The video source may also be from external source 19, such as an external hard disk or a computer. Operation of controller 5 may be controlled using a PC and software running on the PC, which tells the controller what to do. A video file residing on the computer may be copied to the internal storage of the controller. Then the video file can be read directly from internal storage instead of from the PC or external source 119.

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External source **19** may be implemented using a computer. Video processor unit controller **5** may also be implemented using, or be part of, a computer. For example, video processor unit controller **5** can be considered a specialized computer with a selection of components for video processing. Further, the video processor unit controller can be implemented as one or more plug-in peripheral boards for a computer, or housed in a separate enclosure, connected to the computer via, for example, a USB connection.

FIG. 2 shows a single panel or tile **6** of a multitiled display **2**. Typically each panel in the display is the same as the other panels and the panels are interconnected to form the display. The panel shown has a square shape, but the panel can be any desirable shape such as triangular, rectangular, trapezoidal, hexagonal, or octagonal. In a specific implementation, the panel is 400 millimeters by 400 millimeters in size.

The panel has a number of pixels **30** arranged in an array of rows and columns. A panel can have any number of rows and columns of pixels. In a specific implementation, the panel has 24 pixels by 24 pixels per panel. This panel has a pixel density of 3600 pixels per square meter. In another specific implementation, the panel has 36 pixels by 36 pixels per panel. This panel has a pixel density of 8100 pixels per square meter.

FIG. 3 shows a first implementation of a pixel element **30** of a panel. For example, there will be 576 (24\*24) or 1296 (36\*36) of these pixels in a panel. This pixel element has three LEDs, each of a different color. An LED **33** is red, an LED **35** is green, and an LED **37** is blue. In other implementations, the colors can be a different color set. With its LEDs, the pixel element can display different colors by mixing of the three LED colors. In a specific implementation, the color depth is 16 bits per color.

FIG. 4 shows a second implementation of a pixel element **30** of a panel. Compared to the pixel element of FIG. 3, there is an additional LED of a different color than the other three. This pixel element has four LEDs, each of a different color. An LED **43** is red, an LED **45** is green, an LED **47** is cyan, and an LED **49** is blue. The cyan LED, which is a bluish-green color, has a wavelength of 505 nanometers or 515 nanometers. In a specific implementation, the color depth is 16 bits per color.

With its LEDs, the pixel element can display different colors by mixing of the four LED colors. The additional pixel element allows the pixel element and consequently the entire display to have an enhanced and greater color gamut than a panel with the three color elements. In other implementations, a pixel element can have more than four LEDs, such as 5, 6, 7, or 8 LEDs per pixel, each a different color than the other pixels.

FIG. 5 shows an implementation of a system of the present invention. In an embodiment, the invention is a technique (such as in software or firmware) that executes on an electronic computing or computer system (e.g., standalone computer, client, or server), such as shown in FIG. 5. FIG. 5 shows a computer system **51** that includes a monitor **53**, screen **55**, enclosure **57**, keyboard **59**, and mouse or pointing device **61**. Mouse **61** may have one or more buttons such as mouse buttons **63**. Enclosure **67** (may also be referred to as a system unit, cabinet, or case) houses familiar computer components, some of which are not shown, such as a processor, memory, mass storage devices **67**, and the like.

Mass storage devices **67** may include mass disk drives, floppy disks, magnetic disks, optical disks, magneto-optical disks, fixed disks, hard disks, CD-ROMs, recordable CDs, DVDs, recordable DVDs (e.g., DVD-R, DVD+R, DVD-RW, DVD+RW, HD-DVD, or Blu-ray Disc), flash and other non-volatile solid-state storage (e.g., USB flash drive or SSD),

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battery-backed-up volatile memory, tape storage, reader, and other similar media, and combinations of these.

A computer-implemented or computer-executable version (e.g., a computer program product) of the invention may be embodied using, stored on, or associated with computer-readable medium. A computer-readable medium may include any medium that participates in providing instructions to one or more processors for execution. Such a medium may take many forms including, but not limited to, nonvolatile, volatile, and transmission media. Nonvolatile media includes, for example, flash memory, or optical or magnetic disks. Volatile media includes static or dynamic memory, such as cache memory or RAM. Transmission media includes coaxial cables, copper wire, fiber optic lines, and wires arranged in a bus. Transmission media can also take the form of electromagnetic, radio frequency, acoustic, or light waves, such as those generated during radio wave and infrared data communications.

For example, a binary, machine-executable version, of the software of the present invention may be stored or reside in RAM or cache memory, or on mass storage device **67**. The source code of the software of the present invention may also be stored or reside on mass storage device **67** (e.g., hard disk, magnetic disk, tape, or CD-ROM). As a further example, code of the invention may be transmitted via wires, radio waves, or through a network such as the Internet.

FIG. 6 shows a system block diagram of computer system **51** used to execute software of the present invention. As in FIG. 5, computer system **51** includes monitor **53**, keyboard **59**, and mass storage devices **67**. Computer system **51** further includes subsystems such as central processor **69**, system memory **71**, input/output (I/O) controller **73**, display adapter **75** (which can include one or more graphics processing units (GPUs)), serial or universal serial bus (USB) port **77**, network interface **80**, and speaker **82**. The invention may also be used with computer systems with additional or fewer subsystems. For example, a computer system could include more than one processor **69** (i.e., a multiprocessor system) or the system may include a cache memory.

The processor may contain multiple processor cores (e.g., two, three, or four or more) on a single integrated circuit. The system may also be part of a distributed computing environment or grid. In a distributed computing environment, individual computing systems are connected to a network and are available to lend computing resources to another system in the network as needed. The network may be an internal or local Ethernet network (e.g., 10, 100, or 1000 megabits per second Ethernet), Internet, or other network. The system may include one or more graphics processing units, which may reside on the display adapter or be part of another subsystem.

Arrows such as **84** represent the system bus architecture of computer system **51**. However, these arrows are illustrative of any interconnection scheme serving to link the subsystems. For example, speaker **82** could be connected to the other subsystems through a port or have an internal connection to central processor **69**. Computer system **51** is but an example of a computer system suitable for use with the present invention. Other configurations of subsystems suitable for use with the present invention will be readily apparent to one of ordinary skill in the art.

The system can have one or more display or graphics adapters, each having one or more GPUs. When a system has multiple GPUs, these GPUs can be connected via the system bus. Or the GPUs may be also directly connected together via another separate bus (e.g., Nvidia SLI bus, ATI CrossFire bus, PCI-E bus, or other). These GPUs typically reside on display

or graphics adapter **75** and connect to the monitor or display via a display interface such as VGA, DVI, HDMI, or Display-Port.

The architecture of a GPU can vary depending on the manufacturer. A GPU is generally a massively parallel processor architecture designed for the specific purpose of performing graphics calculations to be displayed on a screen. Many calculations and transformations are used to render three-dimensional graphics and animation in real-time. The GPU accelerates such tasks. However, there are many tasks that a GPU is not designed and cannot handle, such as general processing tasks which is handled by the CPU. Features of a GPU can be incorporated in an application specific integrated circuit (ASIC) or field programmable gate array (FPGA).

Some components of a GPU include shaders, vertex processors, texture processors, fragment processors, z-compare and blend components, texture cache, vertex cache, and shadow buffer. Some shaders include vertex shaders, geometry shaders, and pixel shaders. A shader is a set of software instructions, primarily to calculate rendering effects in the GPU.

Computer software products may be written in any of various suitable programming languages, such as C, C++, C#, Pascal, Fortran, Perl, Matlab (from MathWorks, Inc.), SAS, SPSS, Java, or JavaScript, or any combination of these. The computer software product may be an independent application with data input and data display modules. Alternatively, the computer software products may be classes that may be instantiated as distributed objects. The computer software products may also be component software such as Java Beans (from Sun Microsystems) or Enterprise Java Beans (EJB from Sun Microsystems).

An operating system for the system may be one of the Microsoft Windows® family of operating systems (e.g., Windows 95, 98, Me, Windows NT, Windows 2000, Windows XP, Windows XP x64 Edition, Windows Vista, Windows 7, Windows CE, Windows Mobile), Linux, HP-UX, UNIX, Sun OS, Solaris, Mac OS X, Alpha OS, AIX, IRIX32, or IRIX64, or combinations of these. Microsoft Windows is a trademark of Microsoft Corporation. Other operating systems may be used. A computer in a distributed computing environment may use a different operating system from other computers.

Furthermore, the computer may be connected to a network and may interface to other computers using this network. For example, each computer in the network may perform part of the task of the many series of steps of the invention in parallel. Furthermore, the network may be an intranet, internet, or the Internet, among others. The network may be a wired network (e.g., using copper), telephone network, packet network, an optical network (e.g., using optical fiber), or a wireless network, or any combination of these. For example, data and other information may be passed between the computer and components (or steps) of a system of the invention using a wireless network using a protocol such as Wi-Fi (IEEE standards 802.11, 802.11a, 802.11b, 802.11e, 802.11g, 802.11i, and 802.11n, just to name a few examples). For example, signals from a computer may be transferred, at least in part, wirelessly to components or other computers.

In the discussion below, this patent uses the DVI interface as an example of a specific application and implementation of the principles of the invention. One skilled in the art will recognize that the principles of the invention are applicable to other interfaces including HDMI, DFP, DisplayPort, SDI, and VGA, with any changes as needed, without departing from the scope of the invention.

FIG. 7 is a diagram of a single pixel module **100** in accordance with an embodiment of the invention. The pixel module

**100** may contain multiple light emitting elements **101**. Three light emitting elements **101** are used in this embodiment; however, the invention is not so limited and any number of light emitting elements **101** may be used. The light emitting elements **101** may be the same or different colors. At least one of the light emitting elements **101** may be capable of being utilized as both a light emitter and a light receptor.

In one embodiment of the disclosure, the light emitting elements **101** are light emitting diodes. Light emitting diodes or LEDs. LEDs are semiconductor devices that emit light when an electrical current flows through them. However, LEDs can also be connected and used as light detectors where they produce an output voltage when illuminated with light. A semiconductor junction diode exhibits some degree of photosensitivity when it receives light of an appropriate wavelength. The spectral response of a specific semiconductor diode when used as a receptor depends on many factors, including the materials used in the manufacture of the diode, the geometry of the junction and the packaging of the diode. The packaging of most semiconductor diode devices aims to inhibit sensitivity to light to maintain stability of the normal properties of the device. However, the construction of an LED normally acts in both directions and allows light into the junction as well as letting it out. LEDs, therefore, can behave and be used as narrowband photodetectors. Suitable circuitry may allow the selectable use of a single LED in either the light-emitting mode or light-detecting mode without adversely affecting its performance as a light emitter.

FIG. 8 is a diagram of a single display module **103** of an LED display in accordance with an embodiment of the invention. Display module **103** includes multiple pixel modules **100**, such as depicted in FIG. 7. Any number of pixel modules **100** may be placed in any arrangement on the display module **103** without departing from the invention. FIG. 8 shows a possible embodiment where the pixel modules **100** are arranged in a 4×4 array on the display module **103**. In this embodiment, each pixel module **100** contains light emitting elements **101**. At least one of the light emitting elements **101** on display module **103** is also capable of acting as a light receptor.

FIG. 9 is a diagram of a control device **104** (which may also be called an input device) and a single display module **103** in accordance with an embodiment of the invention. Control device **104** may be a handheld device containing a light emitting element **105**, such as a laser, LED, or other light emitter known in the art, which emits a coded signal **106**, such as a coded light signal. The signal **106** may be radiation or light of a wavelength suitable for reception by a light emitting element **101** acting as a detector.

The optimal color of light used for transmission may not be the same as the light emitted by an LED when it is used as an emitter. For example, red LEDs are typically most sensitive to orange light when used as a receptor and, in general, an LED is usually sensitive as a receptor to light slightly shorter in wavelength than the light it emits when acting as a light source. The coding system used in signal **106** may be selected from many coding systems, including, but not restricted to: pulse-width modulated, pulse-amplitude modulated, phase modulated, amplitude modulated, and frequency modulated.

Light emitting element **101** acts as a receptor on display module **103** and receives the coded signal **106**. A processor, e.g., a local microcontroller or other logic element (not shown), processes and decodes the signal **106**. The processor may be attached to the display module **103**, or the processor may only need to be electrically connected to the display module **103**.

For purposes of discussion, we describe a single light emitting element being used as a receptor. However any number, one, two, three, or all the LEDs of a pixel element, can be used as receptors. These multiple LED receptors can act like a compound eye to further enhance the detection of signals. Combining multiple LEDs together for detection increases the detection band to be greater than the band available with a single LED. Therefore, the detection sensitivity increases and the receptors will be able to detect even more subtle light changes.

In a specific embodiment of the invention, the coded signal **106** from the control device **104** will contain data allowing the setting of address of display module **103**. This system allows an individual display module **103** to be replaced in a display system and then “shot” with the control device **104** to address the display module **103**. A display module **103** may thus be “hot-swapped” or replaced in a maintenance situation while the display is in normal operation with a minimal amount of disruption. There is no need to switch the display into a special maintenance or test mode which would be visible to the audience or a viewer.

In a further embodiment, additional security for the system is provided by ensuring that the coded signal **106** from the control device **104** is dynamic and unique. To facilitate this process, the coded signal **106** may include data identifying the specific control device **104** sending the signal. In subsequent operation, the display module **103** may confirm that this particular interactive device **104** is authorized to send commands.

FIG. **10** is a diagram of the control device **104** and multiple display modules **103** in accordance with an embodiment of the invention. A larger display is illustrated here containing multiple display modules **103**, each of which contains multiple pixel modules **100**. By a similar arrangement to that described above for FIG. **9**, a display module **103** may be hot-swapped or replaced in a maintenance situation while the display is in normal operation with a minimal amount of disruption. There is no need to switch the display into a special maintenance or test mode which would be visible to the audience or a viewer. The control device **104** may be positioned close to a specific display module **108** such that only one or more of the light emitting elements **101** acting as light receptors on that display module **108** receive the coded signal **106** and only that single display module **108** will respond to that coded signal, thereby leaving other display modules **103** unaffected.

In an implementation, the display panels can receive control information from control device **104**. The control information can be, e.g., address information as discussed above. Or the control information can be used to control lighting in the room, brightness of the screen, contrast of the screen, and the like. For example, by supplying a dim screen code from the control device, the user can dim the screen of the display without needing to be connected through a wired or network connection to the display. In fact, the panel may be disconnected from a network of the display system, and the control device can still be used to control functionality of the display. The data sent by the control device and received by the photoreceptors of the screen can be stored in a memory of a panel or processed by a processor of a panel, or a combination of these.

FIG. **11** shows display **2** with panel **6** having LED pixel elements, where at least one these elements in addition to emitting light, also detects light. There are rows and columns of panels, similar to shown in FIG. **1** and described above. Each of the panels and pixels is electrically connected to a

processor (via an electrical connection **1102**), which may be part of a video controller like described above).

This processor may be a general purpose processor like a CPU or a specialized processor like a GPU. The processor may be housed or enclosed in the panel, where each panel has its own processor. Or one or more processors may be external to the display, and connected to the panels electrically via an interface cable. Further in another implementation, there may be a external processor that works in conjunction with individual processors in each panel.

Any light changes will be detected by the photodetectors in each of the pixel elements. These light changes may be from a light source such as described previously in FIGS. **9** and **10**. Further, the light changes detected may be from an input source **1106** that is not an active light source (such as a person’s finger, hand, head, leg, or foot). The photodetectors will detect changes in the ambient lighting in front of the display.

Because the pixel elements and display panels are arranged in an array, the processor can detect the motion, positioning, and change in positioning of the input source. For example, if a person were to move a hand from left to right, the processor would, through the photodetectors, detect that this has occurred. Also, if the hand can move to a specific position of the screen and the photodetectors and processor can detect this too. Since the photodetectors detect light movement, the hand or input source does not need to actually touch the screen.

This display that has both light emitting and light detecting elements. Interactive application software **1115** can use both features to make interactive content for users. The interactive application is stored in a memory **1109**, which controls the operation of the processor, and receives motion and positioning information from the processor too.

For example, the interactive application may be a game program that shows an avatar on the screen. The user stands in front of the screen and waves his two arms. The interactive application receives this information about motion and directs the avatar on display to move its arms in the same way. There are number ways interactive applications can use the features of a display of the invention.

A specific flow for an interactive display of the invention is presented below, but it should be understood that the invention is not limited to the specific flows and steps presented. A flow of the invention may have additional steps (not necessarily described in this application), different steps which replace some of the steps presented, fewer steps or a subset of the steps presented, or steps in a different order than presented, or any combination of these. Further, the steps in other implementations of the invention may not be exactly the same as the steps presented and may be modified or altered as appropriate for a particular application or based on the data.

An interactive display flow, which can execute on a process and stored in memory, is:

1. Display an initial interactive screen for a user, where the user can interact with graphical elements of the display. For example, this screen may have buttons, avatars, graphics objects, and other types of elements. The interactive screen may be a game program.

2. The processor determines a baseline lighting level of one or more input sources (e.g., one or more users) in front of the display.

3. Upon motion by the input source or user, the interactive software application receives information about this motion. For example, the user may have indicated touching of a button places at a particular location on the display. The user may

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have made a hand gesture such as flipping a page. The user may move two or more motions such waving both hands.

4. The interactive program determines the motion the user makes and alters what is displayed on the screen in response. For example, if the user motions like touching a first button on the screen (without actually touching the screen), the program displays a second interactive screen. While if the user motions like touching a second button on the screen, at a different location than the first button, the program displays a second interactive screen different from the first.

5. The interactive program can also move objects on the screen in response to how the user moves. For example, if the user is dancing, a simulated partner on the screen can appear to dance with the user. The user can make a motion like hitting a ball, a ball object being drawn by the processor is altered on the display to appear as though the user hit the ball (and recreates the accompany physics).

In particular, the interactive program shows an object on the screen. The photodetective and consequently the interactive program detects motion by the user. The interactive program draws the object on the screen differently than was previously drawn in response to the user's motion.

This description of the invention has been presented for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form described, and many modifications and variations are possible in light of the teaching above. The embodiments were chosen and described in order to best explain the principles of the invention and its practical applications. This description will enable others skilled in the art to best utilize and practice the invention in various embodiments and with various modifications as are suited to a particular use. The scope of the invention is defined by the following claims.

The invention claimed is:

1. A light emitting display unit, comprising:

a pixel module comprising a first LED for emitting a first color of light, a second LED for emitting a second color of light, and a third LED for emitting a third color of light, wherein the first, second, and third colors of light are different colors of light, the first LED is configured to emit light and further configured to detect light, and the second and third LEDs are configured to emit light and not detect light; and

an interface coupled with the pixel module, wherein the interface receives an output signal and transmits an input signal wherein

the interface is calibrated to transmit the input signal to the pixel module, the input signal corresponds to emitting light within a first range of wavelengths by the first LED, and the first LED is configured to emit light within the first range of wavelengths,

the interface is calibrated to receive the output signal from the pixel module, the output signal corresponds to light detected by the first LED within a second range of wavelengths, and the first LED is configured to detect light within the second range of wavelengths,

a first wavelength within the first range of wavelengths is emitted by the first LED, and

a second wavelength within the second range of wavelengths detected by the first LED are different wavelengths.

2. The light emitting display unit of claim 1 wherein the input signal is a coded signal.

3. The light emitting display unit of claim 2 wherein the coded signal is coded in at least one of pulse-width modulation,

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pulse-amplitude modulation, phase modulation, amplitude modulation, and frequency modulation.

4. The light emitting display unit of claim 1 further comprising an input element configured to emit the output signal.

5. The light emitting display unit of claim 4 wherein the input element comprises a light emitting element configured to emit the output signal.

6. The light emitting display unit of claim 5 wherein the light emitting element of the input element comprises one of a light emitting diode and a laser.

7. The light emitting display unit of claim 5 wherein the input signal comprises at least one of infrared radiation, ultra-violet radiation, visible light, and reflect light emitting from the light emitting element of the input element.

8. The light emitting display unit of claim 1 wherein the first, second, and third colors include red, green, and blue.

9. The light emitting display unit of claim 8 wherein the pixel module comprises a fourth LED that is a cyan LED.

10. The light emitting display unit of claim 1 further comprising a processor electrically connected to the pixel module and configured to supply an address for the pixel module.

11. A light emitting display system comprising:

a plurality of display units, wherein the display units are detachably coupled to form a display portion of the light emitting display, each display unit is individually detachable from the display portion without detaching other of the display units from the display portion,

each of the display units comprises a light emitting element configured to emit light and configured to detect light, the light emitting element emits light at a first range of wavelength,

the light emitting element detects light at a second range of wavelengths and is coded light, and

each display unit has a unique address assignable individually via coded information transmitted from a remote control device in the second range of wavelengths to the light emitting element of the display unit and the coded information comprises first address information for an address for the display unit,

wherein a first wavelength within the first range of wavelengths is emitted by the light emitting element, and

a second wavelength within the second range of wavelengths detected by the light emitting element are different wavelengths; and

a processor, electronically coupled to the display units, wherein the processor receives the first address information from a first display unit of the plurality of display units when at least one of the light emitting elements of the first display unit receives the first address information in the coded information that is transmitted at the second wavelength in the second range of wavelengths from a remote control device,

the processor electronically addresses the first display unit of the plurality of display units with second address information that includes the unique address for the first display unit, and

the second address information is based on the received first address information.

12. The light emitting display system of claim 11, wherein each of the plurality of light emitting elements is configured to receive a signal.

13. A method of communicating with a light emitting display unit comprising:

receiving a coded signal with a light emitting element disposed on a pixel module of the light emitting display unit of a display having a plurality of display units, wherein the light emitting element is capable of emitting

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light at a first wavelength from a display signal and receiving light to generate a response signal at a second wavelength,

wherein the light emitting element comprises calibrating the light emitting element to emit light at a first wavelength and calibrating the light emitting element to receive light at a second wavelength, and

the coded signal is at the second wavelength and includes address information for an address for the display unit that includes the pixel module and the light emitting element that receives the coded signal;

setting an address of the light emitting display unit that includes the pixel module and the light emitting element that receives the coded signal based on the address information;

processing the signal with a processor electrically connected to the light emitting display unit, wherein the processing includes ignoring light received by the light emitting element at the first wavelength;

producing a request of address by the processor for the pixel module; and

addressing the pixel module of the light emitting display unit by the processor using the address based upon the request of address.

14. The method of claim 13 wherein the pixel module is addressed by the processor.

15. The method of claim 13 wherein the pixel module is addressed by another processor.

16. The method of claim 13 further comprising:

producing the signal with an input element; and

authorizing the input element to communicate with the light emitting display unit.

17. A method of communicating with a light emitting display unit comprising:

receiving a coded signal at a first wavelength within a range of wavelengths with a light emitting element, calibrated during manufacture to detect the range of wavelengths, disposed on a pixel module of the light emitting display unit, wherein the light emitting element emits light at a second wavelength, beyond the range of wavelengths, and the coded signal is coded with digital information;

processing the digital information in the coded signal with a processor electrically connected to the light emitting display unit;

producing an output by the processor using the digital information in the coded signal received in the first wavelength for controlling the pixel module; and

controlling the pixel module of the light emitting display unit based upon the output.

18. The method of claim 17 wherein the controlling the pixel module comprises at least one of controlling a color of light emitted from the light emitting element of the pixel module and controlling an intensity of light emitted from the light emitting element of the pixel module.

19. The method of claim 17 wherein the coded signal comprises at least one of infra-red radiation, ultra-violet radiation, visible light, and reflect light emitting from the light emitting element of the input element.

20. A method comprising:

displaying a graphical object on an LED screen, wherein the LED screen comprises a plurality of panels comprising LED elements capable of emitting light at a wavelength used to show the graphical object is also electrically connected to operate as a photodetector for a range of wavelengths, wherein the wavelength is not within the range of wavelengths;

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providing a first display panel of the plurality of panels comprising a light emitting element capable of emitting light at a first wavelength not in the range of wavelengths and is electrically connected to operate as a first photodetector for a second wavelength in the range of wavelengths;

providing a second display panel of the plurality of panels comprising a light emitting element capable of emitting light at a third wavelength not in the range of wavelengths and is electrically connected to operate as a second photodetector for a fourth wavelength in the range of wavelengths, different than the first photodetector for the second wavelength;

using the first and second photodetectors to detect motion from an input source in front of the LED screen which is not an active light source; and

in response to the detected motion by the first and second photodetectors, using a processor coupled to the first and second photodetectors to move the first object on the LED screen from one position on the screen to a different position on the screen.

21. The method of claim 20 wherein the input source is a human hand.

22. The light emitting display unit of claim 1 wherein the light emitting element is a narrowband detector.

23. The light emitting display unit of claim 1 wherein the light emitting element is a single narrowband detector.

24. The light emitting display unit of claim 9 wherein the light emitting diode further comprises a cyan light emitting diode.

25. The light emitting display unit of claim 1 wherein the first range is approximately in a visible spectrum of light.

26. The light emitting display unit of claim 25 wherein the second range is approximately in the visible spectrum of light.

27. The light emitting display unit of claim 8 wherein the light emitting diode includes a 16 bit depth of color.

28. The light emitting display system of claim 11 wherein the light emitting element is configured to detect light at the second range of wavelength based on a geometry of the light emitting element.

29. The light emitting display system of claim 11 wherein the light emitting element is configured to detect light at the second range of wavelength based on a packaging of the light emitting element.

30. The light emitting display system of claim 11 wherein the light emitting element is configured to detect light at the second range of wavelengths based on a material used in the manufacture of the light emitting element.

31. The light emitting display system of claim 11 wherein the plurality of display units includes a first image and a second image, wherein the second image is based on the first image and the detected light at the light emitting element.

32. The method of claim 13 further comprising:

at a first time, emitting light at the light emitting element; and

at a second time, generating the response signal.

33. The method of claim 20 further comprising before using the photodetector to detect motion, determining a baseline profile of lighting.

34. The method of claim 33 wherein determining the baseline comprises processing information from the LED element.

35. The light emitting display unit of claim 1 wherein the pixel module is configured to detect light within the second range of wavelengths that comprises a range determined during a manufacture of the light emitting element.

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36. The light emitting display unit of claim 1 wherein the light emitting display unit further comprises:

- a second pixel module comprising a second light emitting element; and
- an attachment mechanism allowing the pixel module to be removably coupled to the second pixel module.

37. The light emitting display unit of claim 1 wherein a third wavelength within the first range of wavelengths is emitted by the light emitting element, and

- a fourth wavelength within the second range of wavelengths detected by the light emitting element are different wavelengths.

38. The light emitting display unit of claim 37 wherein the first and fourth wavelengths are different wavelengths.

39. The method of claim 20 wherein the in response to the detected motion by the first and second photodetectors, using a processor coupled to the first and second photodetectors to move the first object on the LED screen from one position on the screen to a different position on the screen further comprises:

- determining if the detected motion is at the first or second photodetector;
- if the detected motion is at the first photodetector, moving the first object on the LED screen in a first direction; and
- if the detected motion is at the second photodetector, moving the first object on the LED screen in a second direction.

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40. The method of claim 20 wherein the first and second display panels are not directly coupled.

41. The light emitting display of claim 1 wherein the interface receives the output signal that is a first coded signal having first coded information, and the first coded information in the output signal corresponds to light that is coded with second coded information for the first coded signal and is detected by the first LED.

42. The light emitting display unit of claim 1 wherein the first LED, second LED, and third LED are semiconductor LEDs.

43. The light emitting display unit of claim 1 wherein each of the first, second, and third LEDs are discrete LED units.

44. The light emitting display unit of claim 1 wherein each of the first, second, and third LEDs are formed of separate substrates.

45. The light emitting display unit of claim 1 wherein the first LED is capable of emitting light of only the first color.

46. The light emitting display unit of claim 45 wherein the second LED is capable of emitting light of only the second color.

47. The light emitting display unit of claim 46 wherein the first and second LEDs of the pixel module are both turned on to emit light of the first color and second color, respectively, whereby the first color and second color emitted at the pixel module blend together to become light of a fourth color that is different from the first and second colors.

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